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THE BOLLWORM OR CORN EARWORM

F. C. BISHOPP

Entomologist, Insects Affecting the Health of Animals

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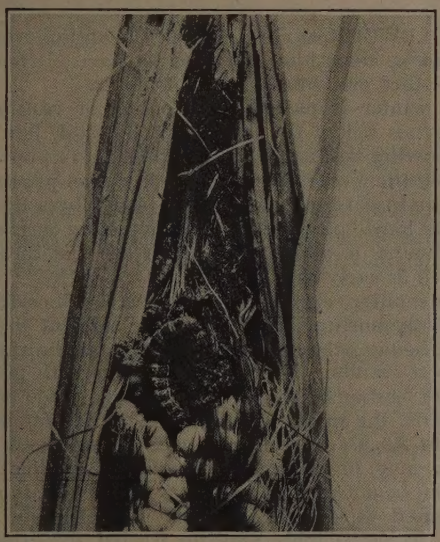

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UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

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THE BOLLWORM or corn earworm is an important pest of cotton, corn, tomatoes, and tobacco. It feeds also on many other cultivated and wild plants.

As the winter is passed in the pupa or resting stage, 4 to 6 inches below the surface of the soil, late fall or winter plowing will cause the death of many pupæ. This is probably the most important of all control practices.

Since the insect increases greatly in numbers late in the season and hard bolls of cotton and ripening corn ears are largely immune to attack, it is important that these crops be matured as early as possible.

The caterpillar, except when it first hatches from the egg, feeds by boring into the fruit or stalk of the plants attacked; hence poisoning must be done at the right time to give best results. Poisoning of cotton with powdered arsenate of lead or Paris green should take place when the corn ears in the main crop become hard; that is, about July 10 to August 20, according to latitude and season. Tomatoes may be largely protected by applications of the poison, begun as soon as injury to the plants appears and repeated at weekly intervals until 10 days before picking. Tobacco buds may be treated by dropping a teaspoonful of a mixture of arsenate of lead and corn meal into them.

Corn used as a trap crop gives some protection to cotton and tomatoes. For cotton the corn should be planted so as to come into silk and tassel when the ears of the early crop are hardening. To protect tomatoes the corn should be planted at intervals so as to be kept in silk through the greater portion of the fruiting period of the tomatoes.

THE BOLLWORM OR CORN EARWORM.[1]

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COTTON BOLLWORM, corn earworm, tomato fruitworm, and false budworm of tobacco are common names applied to one and the same insect when it is found attacking these various crops. In fact the insect is a very general feeder, attacking many wild plants as well as garden vegetables, alfalfa, cowpeas, and the crops indicated above.

The bollworm, or corn earworm as it is most widely known, occurs as a pest in practically all parts of the United States. The corn crop is widely affected, and the loss to this crop, including sweet corn, exceeds the damage to any other single crop. This was estimated in 1905 to be about $18,000,000 annually, and in the absence of the later statistics it is safe to assume that the annual losses at the present time greatly exceed this amount. The loss to cotton raisers on account of its depredations was placed at $8,500,000 each year. This injury to cotton is most severe in parts of Texas, Oklahoma, Arkansas, Louisiana, Mississippi, and Alabama. (See fig. 1.) The total annual tax of this insect on the farmer can be conservatively placed at nearly $30,000,000. Despite these startling figures, the fact that the insect has been present as a pest in this country for many years has caused most farmers to become tolerant of it. Under the present stress

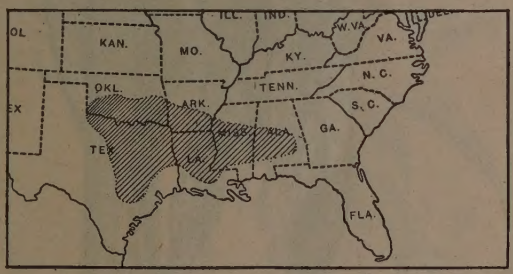

FIG. 1.—Map showing approximately the area in which the bollworm inflicts severe injury on cotton.

[1] Known scientifically as *Chloridea obsoleta* Fab.; order Lepidoptera, family Noctuidae.

of world need it becomes doubly necessary to put forth every effort to reduce these losses to a minimum.

CHARACTER OF INJURY.

The character of attack on all the principal crops affected is similar. The caterpillars usually bore into and feed within the

FIG. 2.—Young corn plant showing injury to growing tip by bollworm. (Quaintance.)

plant tissue. The first damage to corn is caused by boring into the bud and eating down into the tender leaves as they unfold. (See

fig. 2.) A little later this injury often seriously affects the tassels before they have opened out, and when the silks appear eggs are laid upon them and young corn earworms burrow down through the silks and attack the small kernels, as shown in the illustration on the title-page. The tips of the ears are injured first; later, especially in tender varieties such as sweet corn, the earworms sometimes eat completely to the base of the ear and almost destroy it. In some regions practically every ear of sweet corn is more or less damaged and throughout the entire country from 70 to 98 per cent of the ears of field corn are attacked. Following this injury molds frequently gain access to the ears and damage them still further. This is especially true during wet seasons. Such conditions are often followed by an abnormally large number of cases of death among stock from the so-called cornstalk disease which seems to be caused by certain molds which develop on corn.

FIG. 3.—Cotton boll with full-grown bollworm eating into tip. Natural size. (Quaintance.)

In the case of cotton the injury is readily distinguished from that caused by the boll weevil, as the squares and more tender bolls are completely eaten out, particularly after the worms have gained considerable size. Occasionally full-grown bolls are gnawed into by the large caterpillars and from one to all of the locks of cotton damaged. (See fig. 3.) Bolls which have become hard are seldom fed upon to any extent.

Injury to tomatoes consists principally of damage to the green or partially ripened fruit, but the young bollworms sometimes also

bore into the growing tips of the plants and occasionally destroy the flowers as well.

In tobacco the injury consists of the penetration of the small leaves in the growing tip, hence the common name of budworm. A related caterpillar,[1] however, attacks tobacco in a very similar manner. A single caterpillar may render several leaves unfit for wrapper by penetrating the bud.

HABITS OF THE INSECT AND HOW IT DEVELOPS.

A general knowledge of the life history and habits of an insect is needed in order intelligently to combat it. The bollworm or corn earworm when mature (fig. 4) is a moth or miller about 1¾ inches across the spread wings. It varies in color from a light brown or olive green to pale yellow and it is commonly seen flying about in the evening. These moths feed upon nectar of various flowers and when mature they deposit from nearly 500 to almost 3,000 eggs. The eggs (fig. 5) are laid on various parts of the plant and to some extent upon weeds and upon the ground. They are white or yellowish in color, oval, and covered with minute ridges running from top to bottom and still smaller ridges across these. They are large enough to be seen readily with the naked eye. The eggs hatch in from 2½ to 8 days or even longer, depending upon the temperature.

FIG. 4.—Bollworm moth with wings folded in natural position. About twice natural size. (Quaintance.)

When first hatched the larvæ or caterpillars are extremely small. They feed here and there on the surface of the plant near where the eggs were laid, but gradually work toward some tender portion within which they can bore. Growth is rather rapid, being completed in about 20 days. The larvæ shed their skins four or five times during this period. When full grown they are about 1½ inches in length. The color varies from pale green to almost black. During the last few days of the life of the caterpillar it is capable of consuming large quantities of food, and it is during this period that it is most destructive.

FIG. 5.—Egg of bollworm moth, side and top views. Highly magnified. (Quaintance and Brues.)

[1] Known scientifically as *Chloridea virescens* Fab.

When fully fed the larvæ leave the plant and burrow into the ground, where they form a kind of cell in which they transform into chrysalides or pupæ of a mahogany brown color. (See fig. 6.) They remain in this quiescent stage for about two weeks except in the case of the last brood in the fall, which stays in the ground until warm weather the following spring. The depth at which these cells are formed by the larvæ in summer varies from 1 to 4 inches according

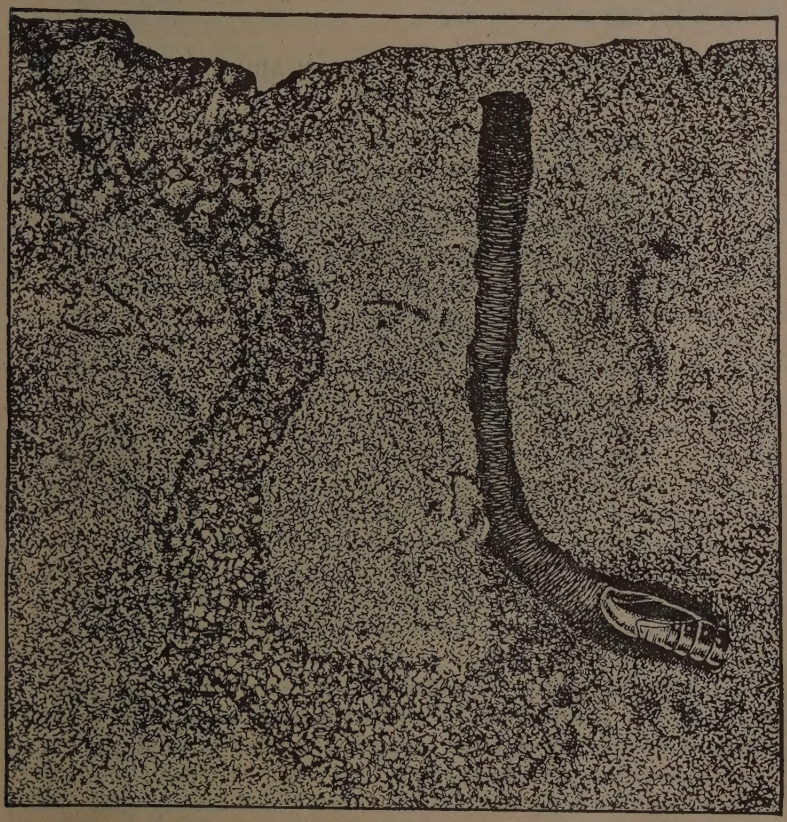

FIG. 6.—Vertical section through soil showing pupa of bollworm in its burrow. About natural size. (Redrawn from Quaintance and Brues.)

to the hardness of the soil. The overwintering pupæ are formed at somewhat greater depths, usually 4 to 6 inches. These chrysalides or pupæ produce moths which in turn lay eggs, thus completing the entire life cycle in about 30 days during warm weather.

That there is a definite connection between weather conditions and injury to the cotton crop by this insect is generally recognized. Cloudy and rainy weather during the latter part of July and through-

out August undoubtedly is conducive to severe injury. This is partially explained by the moistening of the soil, which permits the moths to emerge without difficulty, and by the stimulating effect of the moisture on the growth of stalks and leaves of cotton at this time, which favors bollworm development. Furthermore, it has been found that the prevalence of such weather conditions lessens the effectiveness of certain minute parasites which prey upon the bollworm in the egg and larva stages.

SEASONAL HISTORY AND RELATION OF ABUNDANCE TO CROP GROWTH.

As has been stated, the bollworm or corn earworm pupa passes the winter months in the soil. Early in the spring the moths begin to come out, and by the time corn is "knee high" they are ready to deposit eggs. On account of the number of pupæ which die from adverse conditions in the winter, the first brood usually is small and the damage is not so appreciable. The second brood appears about the time the corn is in silk and tassel, and the number of moths is increased greatly. The caterpillars reach their full development about the time the ears of early corn become hard. In the South the third generation is the one which is destructive to cotton, the corn at this time being for the most part hard and dry. In the North this brood develops on late corn and other crops, and under usual weather conditions is the last brood of the season, while in the South four or even five broods may develop during a year. The late caterpillars feed on various green crops, including late cotton, cowpeas, and alfalfa. Thus in the Southern States most of the overwintering insects will be found in soil where cotton and other late-growing crops are raised, while in the North the late cornfields probably contain most of them.

The bollworm shows a preference for corn when this crop is "silking," and this fact can be utilized to some extent in protecting cotton and other crops from injury, as will be pointed out later. These caterpillars are cannibalistic, and when they come in contact with one another many of them are killed, which usually reduces the number of worms developing in a single ear to one, two, or at most three, whereas dozens of eggs may be laid upon a single strand of corn silk.

CONTROL MEASURES.

As a result of the study of the life history and the seasonal history of this insect it will be seen that there are four outstanding facts which can be made use of in control work:

First, the insects spend the winter in the pupa stage in the ground. They also spend some time between generations in the soil. This

enables the farmer to destroy many of them by plowing at the proper time.

Second, the caterpillars feed for a time on the surface of the leaves before penetrating the tissues of the plant. This is the only time during which the insect can be poisoned successfully.

Third, the number of bollworms or earworms increases greatly as the season advances. This indicates a need for hastening the maturity of all crops affected.

Fourth, since green corn is preferred as food, it is possible to utilize this to some extent as a trap to protect cotton and other crops.

It has been found that by modifying slightly the usual farm practices much can be done toward lessening bollworm or corn earworm injury. Fortunately these modifications are such as to increase crop production, regardless of the presence of this insect. Another important point is that some of the recommendations for controlling this insect are equally applicable, irrespective of the crop grown.

FALL AND WINTER PLOWING.

Probably the most important single step in controlling the bollworm consists of thorough breaking of the land in which the worms have buried themselves for the winter, at some time during the late fall or winter months. Particular attention should be paid in this respect to the crops which are known to have bollworms developing during the late fall months. The practice of fall and winter plowing, aside from bollworm control, is desirable because it conserves moisture, puts the ground in better condition for planting, and enables the farmer to plant at the proper time the following spring.

It has been found that the breaking up of the cells in which the insect is spending the winter results in the destruction of practically every pupa through the action of cold and moisture. Since the cells of the wintering brood are formed at from 4 to 6 inches beneath the surface, it is important that the plowing be deep enough to reach them. It is desirable to plow or deeply disk the fence rows and other places where bollworms may have fed on various plants. This is also beneficial in destroying eggs of grasshoppers and hibernating places of chinch bugs and other destructive insects.

CONTROL ON CORN.

CULTURAL METHODS.

In addition to the employment of fall and winter plowing, the injury to corn can be reduced somewhat by planting as early in the spring as is compatible with getting the ground into good condition. The corn should be as nearly uniform in age as possible and every effort should be made to hasten growth and maturity. Keeping the

crop free from weeds and grass during the growing season not only tends to increase the yield but also destroys hiding places of the moths.

POISONING CORN.

Unfortunately no very satisfactory method of poisoning the worms on corn has been devised. As many as 50 per cent may be destroyed, but the remainder will gain entrance to the ears and produce the usual injury. Recent work conducted in Kansas by Mr. J. W. McCulloch and in Missouri by Mr. Leonard Haseman indicates that the application of powdered arsenate of lead to the silks as soon as they begin to appear will reduce the injury considerably. Owing to the rapid growth of the silk and the fact that the eggs are deposited continuously, it is necessary to make a light application of poison at three or four day intervals to secure good results. In the experiments mentioned the poison was blown onto the ears with a dust gun or applied by hand with a cheesecloth bag. The cost of application and material probably would more than offset the advantage gained under field conditions, and this method will be more applicable in protecting sweet corn or corn grown especially for roasting ears, and in reducing the amount of injury to special selections grown for seed purposes.

CONTROL ON COTTON.

CULTURAL PRACTICES.

Several of the measures best calculated to reduce bollworm injury in the cotton-growing States are equally effective in checking the ravages of the boll weevil. No loss of money or energy results from putting such cultural practices into effect, even though the bollworm should not appear in very destructive numbers in any particular year.

To protect cotton from bollworm injury it is important (1) that early maturing seed be selected; (2) that the crop be planted as early as is consistent with getting a good stand and having the crop start off well; (3) that poor lands be fertilized, and cultivation be thorough and frequent. Every step should be taken which will hasten the early maturity of fruit and keep the plants in a healthy, growing condition. The reason for this can be seen readily when we know that the bollworms pass to the cotton when the corn becomes mature, and that hard bolls are not subject to injury. Since the moths hide in the foliage when the growth is luxuriant, those varieties which make comparatively small stalk without a superabundance of leaves are desirable. This also hastens the drying out of the bolls after they are grown. The early and complete destruction of cotton stalks as recommended for the boll weevil will prevent the maturity of many late bollworms and destroy a considerable number outright.

POISONING COTTON.

The use of poisons against the bollworm has met with considerable success when the poisons have been applied at the proper time. Attention has been directed to the fact that a large proportion (from 60 to 80 per cent) of the eggs deposited in cotton fields are placed elsewhere than on the squares and flowers. Following hatching, therefore, it is necessary for the young larvæ to travel a considerable distance before penetrating the fruit. During this rather aimless wandering the insect eats here and there from the surface of the leaves and stalks. During this short period in the existence of the larva it is susceptible to the action of various arsenical poisons.

The time for applying the poison varies slightly from year to year. The first application should be made when the corn ears are becoming hard. The actual date will range from about July 10 to August 20, according to latitude and seasonal conditions. Powdered arsenate of lead or Paris green should be used. The former is less poisonous to the insect but is not so apt to cause burning of the foliage. At this season the slight burning resulting from the use of Paris green is really immaterial. Arsenate of lead has the advantage of sticking firmly to the plants; even a light rain will not wash it off after it has once dried on. The poison can be applied in dust form or as a spray. The former usually is more practical, since water is not usually found in proximity to cotton fields, and more time is required in applying poisons in liquid form. If Paris green is sprayed on, it should be used at the rate of 1 pound to each 50 gallons of water, and 50 gallons will cover about 1 acre. The powdered arsenate of lead should be used at the rate of about 5 or 6 pounds per acre, and the Paris green, when used in dust form, at the rate of 2 to 3 pounds per acre, according to the size of the plants. When Paris green is used a field can be covered more economically by mixing the material with two or three parts of air-slaked lime, which also lessens the likelihood of burning. The poisons may be put on by the old-fashioned "bag and pole" method or, better, with a power blower or a hand blower mounted on a light wagon. The bag and pole method is fairly efficient and obviates the purchase of machinery.

These outfits are not difficult of construction. A 4-inch board about 18 inches longer than the distance between the rows is used for the pole. To form the bags at either end, four blocks of the same material, each about 4 inches long, are nailed endwise to the underside of the pole. One of these is placed at each end and the other two about 16 inches from these to form the ends for the rectangular-shaped bags. An inch or one and one-half inch hole is then bored through the pole about 8 inches from either end for pouring the poison into the bags. These holes are closed with corks when the outfit is in use. The sides of a rectangular piece of cloth are then tacked

along each edge of the pole, and the ends to the sides and bottom of the blocks. If unadulterated Paris green is to be used, 8-ounce duck may be used for the bag, but lighter material is necessary for powdered arsenate of lead or Paris green mixed with lime. One of these outfits is shown in figure 7. The poison sifts out over the plants as the pole is jarred by striking it with a stick as it is carried across the back of a mule ridden between the cotton rows. Two rows are thus treated at once and from 15 to 20 acres can be covered by one man during the early morning and evening hours which are suitable for the work. It is best to apply the poison when the plants are moist with dew so that it will adhere to the foliage. It is also necessary to avoid windy periods.

Care should be taken to protect the animals used in this work from eating the poisoned plants and as far as possible from becoming too much covered with the poison.

Best results can be secured by making two or three applications of poison at intervals of about a week. In case of rain following the use of Paris green, the crop should be treated again immediately. In

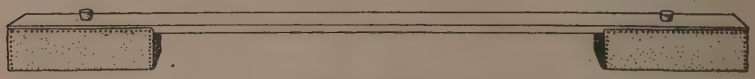

FIG. 7.—"Bag and pole" for use in distributing poison in bollworm control.

rather extensive experiments conducted during 1905–6 an average expenditure of $5.21 per acre, over the cost of poison and the expense of application, resulted. Some of the plants were treated once and others received two applications.

On account of the sporadic occurrence of bollworms in great numbers in most regions it is rather difficult to foresee just when serious injury is to occur, but it would no doubt be profitable to apply poison each year in the portions of Texas and Oklahoma where bollworm damage is general and most severe.

CORN AS A TRAP CROP TO PROTECT COTTON.

Since the bollworm prefers corn to cotton or most other plants for food it is possible to concentrate the larvæ on corn and keep them from becoming so numerous on cotton. To effect such a result it is important that corn be planted at such a time as to be in silk and tassel about the 1st of August. If it matures too early it will act only as a breeding place for bollworms, which will mature as the ears harden and a short time later transform to moths which in turn will deposit eggs over adjacent cotton fields. On the other hand, if the plants are in an attractive state, the moths, which fly quite freely,

will assemble in the corn from considerable distances and deposit most of their eggs on the corn plants. These eggs will hatch and the young larvæ, being so numerous, will destroy one another to such an extent that usually not more than a few out of the many hatching on the silk of each ear will reach maturity.

One plan of planting the trap rows consists of leaving belts from 10 to 40 feet wide across the field at the time the cotton is planted and about June 1 planting this space with Mexican June corn in rows 5 or 6 feet apart. About 10 days later a row of cowpeas may be planted between the corn rows, thus leaving room for cultivation and at the same time furnishing attractive places for the bollworm moths, which will concentrate in the trap rows in great numbers. While any variety of corn may be used, the Mexican June corn is more desirable in the Southwest on account of its resistance to drought.

Another system is to plant patches of June corn and cowpeas here and there over the plantation following such crops as oats, wheat, and potatoes. This provides a trap crop for the bollworm, results often in a good yield of corn, and in a crop of cowpeas, which is valuable as green manure or for food and forage.

CONTROL ON TOMATOES.

The worms usually begin attacking the tomato crop before the fruit is set and continue their work until frost. At first they feed on the tender leaves at the tips and burrow into the stems. Later they attack the buds and flowers, then the small fruits, and continue the damage even when the fruit is ripening.

The feeding habits of the larvæ early in the season render the use of arsenical poisons effective, and as the worms pass from one fruit to another poison will destroy many of them later, but it is not advisable to use poisons later than 10 days before harvesting begins. As the first clusters of tomatoes are of greatest value, especially in the trucking regions of the South, the early use of poisons where bollworms cause trouble undoubtedly would net good returns.

On tomato lead arsenate should be used rather than Paris green in order to prevent burning. This material may be applied in dust form or as a spray. For the spray about 2 pounds of the lead arsenate in the paste form and 1 pound of zinc arsenite dissolved in 50 gallons of water should be used per acre. The use of about 3 pounds per acre of powdered arsenate of lead applied as a dust is recommended. The first application should be made as soon as the moths are observed in the field or injury to the leaves and stalks is noticed, and succeeding treatments should follow at about weekly intervals. If fungicides (such as Bordeaux mixture) are used against diseases of the tomato, the arsenical may be added to these.

While some are averse to using poisons on crops of this kind, no injurious effects are likely to occur, especially if the applications are discontinued some time before picking begins. The early treatments are most effective, as at this time the worms are not feeding within the large tomatoes and are thus most easily reached.

CORN AS A TRAP CROP TO PROTECT TOMATOES.

The principle of trapping described for the protection of cotton can be utilized in controlling the bollworm on tomatoes. It is advisable, however, to modify it somewhat. As the moths deposit eggs on the plants during a considerable period, it is desirable to have corn in silk and tassel from the time the fruit begins to set on the tomatoes until harvesting is over. It is advisable to use small areas immediately adjacent to tomato patches and plant portions of these at two-week intervals, thus bringing a succession of plants into silking during the fruiting period of the tomato. If a large acreage is in tomatoes, it is advisable to plant a few strips of corn through the field in addition to those on the margins. As the ears become sufficiently mature for roasting they should be gathered to prevent the escape of the worms. If these worms are allowed to leave the ears in the fields, they will produce moths which in turn may cause an infestation of the tomatoes. Either field corn or sweet corn may be used as a trap crop under these conditions.

CARE OF INFESTED FRUIT.

The poison treatment should be supplemented by picking and destroying all wormy tomatoes. These should not be left in the field, as the worms will emerge from them and return to the plants or produce moths which will multiply greatly the number of the worms later in the season.

CONTROL ON TOBACCO.

A number of authorities state that where the false budworm[1] is injurious to tobacco, notably in Georgia and Florida, damage can be prevented largely, though at a considerable expense, by sifting by hand into the bud a mixture of powdered arsenate of lead and corn meal. One pound of the poison is used to 75 pounds of corn meal[2] and applications to shade tobacco are made twice a week. No doubt corn can be utilized as a trap crop to some extent as recommended for the protection of tomatoes.

[1] A local name for the bollworm, *Chloridea obsoleta* Fab.

[2] Extensive experiments have been made with many carriers, but none of them have given satisfactory results except the corn meal.

INEFFECTIVE METHODS OF CONTROL.

The burning of lights for the attraction of moths in fields is not uncommon in certain sections and the idea of trapping the moths by various devices is advocated often. Both of these methods have been tested thoroughly and found of little or no value. In the first place most of the moths caught are males, or females which have deposited their full quota of eggs, and in the second place a great many beneficial insects which prey upon the bollworm in different stages are destroyed. The placing of poisoned sweets in pans in the cotton field also has been found to be a useless practice.

PUBLICATIONS OF UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO INSECTS INJURIOUS TO COTTON OTHER THAN THE BOLL WEEVIL.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

The Fall Army Worm, or "Grass Worm," and Its Control. (Farmers' Bulletin 752.)

The Red Spider on Cotton and How to Control It. (Farmers' Bulletin 831.)

Carbon Disulphid as an Insecticide. (Farmers' Bulletin 799.)

How Insects Affect the Cotton Plant and Means of Combating Them. (Farmers' Bulletin 890.)

The Argentine Ant: Distribution and Control in the United States. (Department Bulletin 377.)

The Red Spider on Cotton. (Department Bulletin 416.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Two Destructive Texas Ants. (Entomology Circular 148.) 1912. Price, 5 cents.

Cotton Stainer. (Entomology Circular 149.) 1912. Price, 5 cents.

Cotton Worm or Cotton Caterpillar. (Entomology Circular 153.) 1912. Price, 5 cents.

Report on Miscellaneous Cotton Insects in Texas. (Entomology Bulletin 57.) 1906. Price, 5 cents.

Cotton Stalk-borer. (Entomology Bulletin 63, pt. VII.) 1907. Price, 5 cents.

Mexican Conchuela in Western Texas in 1905. (Entomology Bulletin 64, pt. I.) 1907. Price, 5 cents.

Notes on Economic Importance of Sowbugs. (Entomology Bulletin 64, pt. II.) 1907. Price, 5 cents.

Plant-bugs Injurious to Cotton Bolls. (Entomology Bulletin 86.) 1910. Price, 20 cents.

Argentine Ant. (Entomology Bulletin 122.) 1913. Price, 25 cents.

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CORRECTION.

Page 13, last paragraph, third sentence, should read as follows:

"For the spray about 2 pounds of the lead arsenate in the paste form or 1 pound of *zinc arsenite* dissolved in 50 gallons of water should be used per acre."